Studies in Agricultural
Capital and Technology

Economics and Sociology
Occasional Paper No. 154

THE FUTURE OF AGRICULTURE IN SOUTHERN BRAZIL: SOME POLICY PROJECTIONS THROUGH A DYNAMIC REGIONAL MODEL OF THE WHEAT REGION, RIO GRANDE DO SUL (1970-1985)

by
Choong Yong Ahn and Inderjit Singh

(Preliminary Draft)

June, 1973

A contributed paper to be presented at the Annual Meetings of the American Agricultural Economics Association in Edmonton, Alberta, Canada, August, 1973 at the session on Economic Policy Including Agricultural Policy and International Trade.

Department of Agricultural Economics and Rural Sociology
The Ohio State University
Columbus, Ohio 43210

CONTENTS

The Future of Agriculture in Southern Brazil: Some Policy Projections Through A Dynamic Regional Model of the Wheat Region, Rio Grande do Sul (1970-1985)*

by

Choong Yong Ahn and Inderjit Singh**

1. Introduction

The purpose of this paper is to trace possible future outcomes under alternative policy assumptions for the agricultural sector in the wheat regions, in Southern Brazil. We do this by extending and projecting a recursive programming model of this region explicitly constructed for this purpose [4]. This model has been used to simulate regional agricultural history in this region for the decade of the sixties and tested on the basis of available data for that period [4,42].

The 1960's saw considerable growth in real agricultural output and a persistent transformation of the regional economy from range livestock production to intensive crop production with a wheat-soybean rotation predominating. This transformation was made possible through a large program of price supports for wheat producers tied to subsidized credits made available for the purchase of modern capital intensive inputs. Preliminary analysis indicates that besides simulating agricultural growth, these policies also brought about distortions in

---

*This research is part of a larger study entitled "Analysis of Capital Formation and Technological Change in Less Developed Countries" under contract to .A.I.D. in the Department of Agricultural Economics and Rural Sociology, The Ohio State University, Columbus, Ohio.

**Respectively, Post-Doctoral Research Fellow, Department of Agricultural Economics and Rural Sociology, Assistant Professor, Department of Economics, The Ohio State University. We would like to thank Professors Dale Adams, Richard Meyer, Norman Rask and Francis E. Walker for their many suggestions. Usual disclaimers apply.

the allocation of resources, a large increase in the demand for credits and an increasing inequality in the distribution of incomes between farms of different size [4,5,41,42].

The purpose of the current exercise is to project regional development into the 1980's under alternative policy assumptions about price supports and credits. The main focus of these projections is to inquire what is likely to happen when i) current policies are continued basically unchanged, ii) current policies are revised, in particular wheat price supports programs or credit subsidies are terminated and iii) to draw some tentative conclusions about the direction which future policy might take.

The next section briefly reviews some of the regional characteristics and recent developments in the region under study; section three outlines the structure of the model including the policy assumptions used for projection; section four reports selected simulation results for alternative policies for the period 1970-1985; section five draws on some of these results in order to evaluate alternative policy outcomes and we conclude with a brief discussion of the complex set of factors that need to be evaluated before future policy choices are implemented.

2. The Study Region

The present study and model structure have been tailored to the predominantly wheat growing areas in the state Rio Grande do Sul in Southern Brazil. This wheat region includes two adjacent areas called the "Planalto Medio" and "Missoes." The region , fairly homogenous with regard to climate and agricultural practices includes some 5.7 million hectares of land under cultivation but has a wide distribution of farm size and hence substantial differences in resource endowments at the farm level.[1]

During the past decade the wheat region has undergone a dramatic agricultural transformation mainly due to a program of wheat price supports accompanied by credit subsidies. The wheat price support program was started in 1962 with the Bank of Brazil standing ready to purchase wheat at the official support price. By 1970, the domestic support price of wheat stood at a level nearly 80 percent above the U.S. export price.[2] The wheat price subsidy increased the ratio of wheat to beef prices in the domestic market nearly twofold between 1962-1970, while the ratio continued to decline, though somewhat slowly, in international markets. As a result, by 1970 the domestic ratio exceeded the international price ratio by more than four times. (Table 1)

This improved profitability for wheat was accompanied by large credits, tied to the purchase of modern inputs, on very liberal terms. Thus after 1964, modern variable inputs, such as seed, nutrients and pesticides, could be purchased 100 percent on credit, at a nominal interest rate of 15 percent per annum, while farmers could obtain long-term, low-interest financing for agricultural machinery with a 25 percent down payment at a 7 percent rate of interest. Meanwhile, the wholesale price index for foodstuffs increased by an average of 60

---

[1]For detailed regional description and agricultural practices see Rask [33,34].

[2]Since 1962 the domestic wheat price has steadily risen above the U.S. export price of wheat. For example, in 1970 the Brazilian Government fixed the domestic wheat price at U.S. $100 per metric ton, while the price for imported wheat is U.S. $58 per metric ton, see Engler [14].

Table 1. Domestic and Import Prices for Wheat and Beef in Brazil (1960-1970) In Cr$/Kilogram*

	Wheat (Unmilled)		Beef (Chilled & Frozen)		Ratio of Wheat to Beef Prices		Exchange Rate*
Year	Brazil (domestic)[a]	U.S. Export Price[b]	Brazil (domestic)[c]	Argentina Export Price[b]	Domestic Market	International Market	Cr$/US$[d]
1960	0.0164	0.0127	0.072	0.0913	0.228	0.139	0.205
1961	0.0224	0.0207	0.104	0.1295	0.215	0.159	0.318
1962	0.04	0.0316	0.173	0.1692	0.231	0.186	0.475
1963	0.0647	0.0407	0.291	0.2387	0.221	0.17	0.620
1964	0.1446	0.1224	0.533	0.9659	0.271	0.126	1.850
1965	0.206	0.1333	0.627	1.407	0.329	0.095	2.220
1966	0.254	0.1378	0.721	1.339	0.352	0.103	2.220
1967	0.3005	0.1740	0.815	1.45	0.369	0.120	2.715
1968	0.3635	0.2358	0.849	2.117	0.428	0.111	3.830
1969	0.4265	0.2539	0.993	2.184	0.429	0.116	4.090[e]
1970	0.49	0.2793	1.10	2.7578	0.445	0.101	4.572[e]

* In New Cruzerios/U.S.$.

Sources:
a) Annuario Estatistico do Brasil, 1960-1970, and Annuario Estatistico do Trigo, 1965-69.
b) Yearbook of International Trade and Statistics, 1960-1970.
c) Annuario Agro-Pecuario, 1960-1970.
d) U.N. Statistical Yearbook.
e) Conjuctura Economica, vol. 17, no. 9, 1970.

percent annually between 1960-66 and 23 percent annually between 1967-71. Thus, in effect, due to inflation the real rate of interest on credit was negative during the entire decade.

This combination of policies made wheat, often double cropped with soybeans, highly profitable, and fueled a program of import substitution in wheat on a massive scale. The area under cultivation and domestic production of wheat increased nearly sevenfold, while domestic production as a percentage of total domestic requirements increased from an average of 9.5 percent for the period 1962-65 to an estimated 50 percent by 1970/71 [15, p.13]. This increased program of self-sufficiency transformed the regional land use patterns from predominantly range livestock production to intensive crop production, accompanied by mechanization on medium and large farms.[3]

We have shown elsewhere that vast differences in farm size in the region, leading to large initial and cummulative differences in resource endowments at the farm level, have had a substantial impact on the "distribution of development." [5,42]. That is, the regional process of development has been highly skewed vis a vis such factors as growth in farm incomes, factor productivities, resource use and policy impacts on farms of different size. We have argued that attempts should be made not only to capture the history of regional aggregates but also their distribution as between farms of different size.

Thus although the wheat region is farily homogenous with respect to agro-climatic conditions, the highly skewed distribution of farms

---

[3]For details see Rask [34] and Engler [14]. For the pricing policy is followed for agricultural commodities in general see Knight [25] and Smith [43]. For the detailed discussions of credit policies and their implications for agricultural development in Brazil, see Adams [2] and Smith [43].

by size has an important bearing on regional development. This distribution is shown in Table 2

Table 2: Farm Size Distribution in the Wheat Region of Rio Grande do Sul in 1967

Class by Hectares	Number of Farms	Percent of Total Farm Area	Land Used (1000 Ha)	Percent of Total Land Used
0-25	65,054	67.32	753,155	13.76
26-50	15,807	16.35	541,606	9.89
51-100	7,485	7.74	506,092	9.25
101-1,000	7,558	7.82	2,112,646	38.61
1,001-10,000	729	0.77	1,557,784	28.49
Total	96,633	100.0	5,471,283	100.00

Source: Estrutura Fundiarra do Rio Grande do Sul - Instituto Brasileiro de Reforma Agraria Delegacia Regional do Rio Grande do Sul.

3. The Model

3.1 Decomposition by Farm Size

The model presented here is similar to the regional models of agricultural development using recursive programming techniques pioneered by Day[8] , further extended by Heidhues[19] and recently applied to agriculture in transition in the LDC's by Singh[39] and Mudahar[30].

These models are based on using a recursive linear programming model to represent the production plans of farms over a period of time. If the production plans for each of the farms in a given region is a solution to a recursive linear program, then the production plans for the region for each year can be obtained througn aggregation under the following assumptions:

(a) the factor and price vectors faced by each farm (or group of farms) are proportional to the aggregate regional factor and price vectors;

(b) the lagged activity-levels and shadow price vectors of each farm (or group of farms) are also proportional to the aggregate ones, and

(c) all the farms (or group of farms) have the same technology.

Furthermore, in order to group farms together say by size, we would have to assume that the lagged activity levels and the resource endowments for each group had been calculated for the group aggregate simply as sums of those of individual farms and the aggregate technical coefficients for the group as means of those of the individual farms in the group.

Under these conditions the primal solution of the aggregate regional program is equal to the sum of the primal solutions of the individual farm programs and dual solution of the regional aggregate program is equal to the mean of the dual solutions of the individual programs [7,8,9].

Since the region is characterized by substantial differences in farm size and resource endowments, we group all farms in the region into three farm size groups - small farms (less than 50 hectares), medium farms (51-300 hectares) and large farms (301-10,000 hectares).[4] All farms within each group are assumed to satisfy the aggregation conditions. Further utilizing the decomposition principle of linear programming, the three farm group models are jointly treated in a single regional model.

[4] No doubt more farm size groups could be considered, but existing computational programs placed an operational limit on the size of the model, forcing a compromise.

Such a model structure shown in Figure 5 is represented by non-empty input-output matrices along the diagonal, and by null-matrices in the off-diagonal zones bordered at bottom by an array of non-empty matrices linking common regional resources for which all the three farm size groups compete.[5]

				Regional Resources
Regional Objective Function	C_1 (t) +	C_2 (t) +	C_3 (t)	
Input-Output Matrix for Each Farm Size	A_1	0	0	$\leq B_1$ (t)
	0	A_2 (t)	0	$\leq B_2$ (t)
	0	0	A_3 (t)	$\leq B_3$ (t)
Regional Coupling Matrix	R_1 (t)	R_2 (t)	R_3 (t)	$\leq B_v$ (t)

Figure 5: Decomposition of the regional model by farm size.

The subscripts 1, 2, 3 and v represent small, medium and large farms and regional resource couplings that are not farm specific respectively. The first row denotes the regional objective function at time t and the sub-vectors of B's are resource limitations specific to each farm size group, while Bv represents a set of regional resource limitations that are not farm specific and for which all farm groups compete. All farm groups operate with identical exogenously given input and output prices and with full

[5] In this study, the decomposition principle is used to distinguish non-aggregatable resource structure specific to each farm size groups and to establish intra-farm competition mechanism for the use of regional strategic resources rather than to partition a larger matrix to solve a mathmatical programming problem. For the theory of decomposition principle, see Hiller an Lieberman [21] , and Lasdon [27] , and for the application of the principle to agricultural production, see De Haen [13] .

knowledge of all available alternative technologies. Common access to regional non-farm specific resources is represented via regional coupling matrices R_i.

The detailed model components shown in Figure 1 are discussed in detail below.[6]

3.2 Programming Components

The regional r.l.p. model is made up of seven basic components: (1) a set of farm activities representing decision variables for farms within the region; (2) an annual objective function measuring the expected revenues from crop sales, the costs of purchased inputs and annual investment charges for resource augmenting investments; (3) a technology matrix representing the traditional and modern input-output structure of cash consumption, farm production, investment, sales, purchase and financial activities; (4) "technical" constraints representing regional resource and financial limitations; (5) "behavioral" constraints representing adaptive, "safety-first" limitations for protection against mistakes of cropping and investment choices, and representing drags on investment due to "learning" and "unwillingness to change"; (6) feedback functions that relate the parameters of the current programming problem to previous decisions; and (7) exogenously given input and output prices, regional supplies of land and labor resources and exogenously estimated consumption requirements by farm size and supplies of regional wage labor, credit and non-farm quasi-fixed capital goods.

Activities are assumed to be linear, finite in number and their levels x_j, $j \epsilon X$ are measured for the regional aggregates. Constraining factors are

[6] A detailed exposition of the model is available in Ahn [4]

identified by an index $i \varepsilon B$. The technical coefficients a_{ij}, $i \varepsilon B$, $j \varepsilon X$ are assumed constant over time and all technology is assumed to be embodied. Positive (negative) coefficients mean a given factor in a net input (output); a zero coefficient indicates a factor not involved in the activity in question. Limitation vectors B_i, $i \varepsilon B$ are also defined at the regional level; positive (negative) coefficients are associated with upper (lower) bounds on activity combinations, zero coefficients with balance constraints.

Using the above notational device the model can be briefly summarized as follows:

Objective Function

$$(1) \quad \text{Max:} \quad \sum_q \sum_j C_j X_{qj}(t) \qquad q \varepsilon Q,\ j \varepsilon X$$

$$t = 1, \ldots, T$$

which defines an additive objective function summed over q farm types differentiated by size representing the expected net cash returns to fixed farm resources for each year. The farm activity set X includes production, $j \varepsilon P$ (wheat, soybeans independent and following wheat, corn, each at two levels of technology (traditonal and modern) and beef cattle raised on either natural or improved summer and winter pastures); purchase $j \varepsilon H$ (variable cash inputs such as hired labor, seeds, fertilizers, and livestock concentrates), sales, $j \varepsilon S$ (of final outputs of wheat, soybeans, corn and beef), financial, $j \varepsilon F$ (including savings, borrowings, and debt repayment) and investment (including the purchase of capital goods, combines and draft animals and land improvement) activities. Intermediate transfer activities $j \in T$ allow for the use of corn and pasture for livestock production and the conversion of natural to improved pasture or crop land. The $C_j(t)$ are the short-run pay-off coefficients and represent current variable costs of the appropriate input (seeds, manure, chemical fertilizers, pesticides, animal draft, fuel, lubricants and labor costs) when j is a purchase activity, the nominal rate of interest when j is a borrowing activity, the regional time deposit rate when j is a saving activity, the expected sales price per unit of output when j is a sales activity and an investment charge estimated on a straight line depreciation basis from the current purchase price of the capital good when j is an investment activity.

We assume that the farmers choice of activity levels are constrained by physical, financial and behavioral limitations represented by a set of inequalities in each production period. That is (1) is subject to:

Land and Family Labor Constraints

$$(2) \qquad \sum_{j \in P,H} a_{qij} X_{qj}(t) \leq B_{qi}(t)$$

$$q \in Q, \quad i \in L$$

where L is the subset of land and family labor constraints by season. Land is exogenously given and fixed while family labor grows at an exogenously given rate equal to the rate of growth of population;

Quasi-Fixed Capacity Constraints

$$(3) \qquad \sum_{j \in P} a_{qij} X_{qj}(t) - \sum_{j \in I} a_{qij} X_{qj}(t) \leq B_{qi}(t) \qquad q \in Q, \; i \in K$$

where K is a subset of limitations on farm power. Given some initial capacities, investment activities allow farms to augment capacities. These physical limitations include tractor, harvesting and draft animal capacities by reason and farm size.

Balance Equations

Balance equations allow the production of intermediate outputs to be used for final outputs, as well as the transfers of additional capacities from investments to current capacities:

$$(4) \quad \sum_j a_{qij} X^*_{qj}(t) \leq 0 \qquad q \in Q,\ j \in P, I, T,\ i \in E$$

where E is the subset of balance equations and $X^*_{qj}(t)$ are the levels of the respective activities estimated by the model at t.

3.3 Feedback Components

What distinguishes recursive programming models from static linear programming models is the dynamic elements. They are introduced through feedback components.

In the present model we allow the augmentation and reduction of quasi-fixed capacities through investments and depreciation. Thus we have capacities in the current period that depend upon previous levels of investments and previous depreciated capacities:

$$(5) \quad B_{qi}(t) = (1 - \lambda_i) B_{qi}(t-1) + \delta_{ij} X^*_{qij}(t-1) \qquad q \in Q,\ i \in K,\ j \in I,$$

where λ_i is the rate of depreciation of the ith capacity and δ_{ij} the addition to the ith capacity per unit level of the jth investment for each farm size q.

Furthermore, financial constraints restrict cash availability by farm size group to previous years gross sales plus previous savings if any with accrued interest and non-farm incomes less cash outlays for production inputs, cash consumption expenditures and debt repayment of previous years borrowings. Thus we have:

Working Capital Constraints

$$(6) \quad \sum_j a_{qij} X^*_{qj} (t) \leq B_{qi} (t) \qquad j \in P, H, I, F \quad i \in G$$

where G is the set of farm specific working capital constraints and

Financial Feedback

$$(7) \quad B_{qi} (t) = \sum_{j \in P} C_j (t - 1) X^*_{qj} (t - 1) - \sum_{j \in H} C_j (t - 1) X^*_{qj} (t - 1)$$

$$+ \sum_{j \in F} C_j (t - 1) X^*_{qj} (t - 1) + \overline{Y}_q (t - 1)$$

$$- \alpha_q (t - 1) \sum_{j \in P} C_j (t - 1) X^*_{qj} (t - 1) \qquad q \in Q \quad i \in G$$

where $\overline{Y}_q$ (t - 1) and α_q (t - 1) are the exogenously estimated level of non-farm incomes and the functional relationship between previous total household consumption expenditures and gross revenues respectively, and C_j are the pay-off coefficients associated with their respective activities previously defined, and X^*_{qj} (t - 1) are the levels of the respective activities in the previous year estimated by the model.

In addition regional borrowings are assumed to be limited to a fraction of previous years gross sales:

$$(8) \quad \sum_{q \in Q} \sum_{j \in F} X^{*}_{qj} \leq \beta \sum_{q \in Q} \sum_{j \in S} C_j X^{*}_{qj} (t - 1)$$

where β is an exogenously given "borrowing coefficient" equal to 0.6 reflecting a rule of thumb criteria used by credit institutions beyond which they won't extend credit, so that the sum of regional borrowings in the current period cannot exceed a fraction of previous years gross revenues in the region.[7]

We further include a set of behavioral constraints which reflect adoption and adjustment behavior and include upper bounds on new technologies defining S-shaped diffusion paths through time and upper and lower crop flexibility bounds on individual crop acreages in any given year to reflect a "safety-first" criteria in response to risk and uncertainty. These constraints depend upon past decisions with regard to new technologies and land allocation to various crop outputs through a recursive feedback.[8]

Thus we define lower and upper bounds on crop acreages by:

a) Flexibility Constraints

$$(9) \quad -\sum_{j \in P} X_{qj} (t) \leq -(1 - \underline{\gamma}_{qi}) \sum_{j \in P} X^{*}_{qj} (t - 1)$$

$$(10) \quad \sum_{j \in P} X_{qj} (t) \leq (1 + \overline{\gamma}_{qi}) \sum_{j \in P} X^{*}_{qj} (t - 1) \qquad q \in Q, \; i \in D$$

where $\underline{\gamma}_{qi}$ and $\overline{\gamma}_{qi}$ are exogenously estimated lower and upper flexibility

[7] The right hand side in this inequality is a component of the coupling constraints B_Y discussed earlier. Two additional regional coupling constraints are included in equation (12) below.

[8] These safety criteria can be introduced as an axiom of behavior, Day [8] , or they can be derived from the safety first, Roy [35] , or focus-loss, Shackle [38], principles of decision making under risk, Boussard [6] , Petit and Boussard [32]. For an early use in agricultural sector analysis see Henderson [20] and Day [8] and for detailed use in dynamic models of developing agriculture see Day and Singh [12] .

coefficients,[9] and production activities P are summed by technologies for each crop separately, and D is the subset of flexibility constraints.

We diffuse the adoption of new technologies (new crops, machines, practices) through time by defining upper bounds on their use by:

b) <u>Adoption Coefficients</u>

$$(11) \quad \sum_{q \in Q} \sum_{j \in I} X_{qj}(t) \leq \min \left\{ \begin{array}{l} \sum_{q \in Q} \sum_{j \in I} (1+\alpha_i)^n X^*_{qj}(t-n) \\ \sum_{q \in Q} \sum_{j \in I} \left[\rho_i \left\{ \bar{X}_{qj}(t) - X_{qj}(t-1) \right\} \right. \\ \left. + X_{qj}(t-1) \right] \end{array} \right. \quad i \in W$$

where α_i and ρ_i are exogenously estimated "adoption" and "adjustment" coefficients for regional data, W is the subset of adoption constraints, and investment activities representing "new opportunities" are considered, and where $\bar{X}_{qj}$ is the "desired" level of the new opportunity. The desired level often is measured by the maximum level of the new technology possible, assuming no demand or supply constraints.[10]

The inclusion of feedback functions through inequalities (4), (6), (7) and (9) - (11) is what distinguishes recursive from ordinary linear programming problems and what gives them their rolling plan nature.

The resource constraints (2) . . . (11) apply to each farm size group and reflect on-farm constraints. In addition these farm size groups are

---

[9] See Day [8] , **Heidhues [19]** , Day and Singh [12], Singh [39] and Miller [29] for the use, justification and various estimation procedures used in estimating these coefficients, and their implications for agricultural models.

[10] See Day <u>et al</u> [11], similar evidence in industrial investment behavior toward new tecynologies and Day [8] , Nelson [31], Abe [1] , Singh [39], Mudahar [30] and Ahn [4] for how these constraints are estimated for agricultural and industrial models.

allowed to compete for regional supplies of wage labor by season, and non-farm supplies of capital goods. The inter-farm competition for these resources is incorporated through the following additional regional constraints:

Additional Regional Coupling Constraints

(12) $\sum_{q} \sum_{j} V_{qij} X_{qj} (t) \leq B_i (t)$ $\qquad q \in Q$, $j \in I, H, F$, $i \in R$

where V is the input-output coefficients in the coupling matrix, and R the subset of regional coupling constraints for each regional resource i.

The complete simulation model is a recursive linear programming system consisting in each period of an ordinary LP problem in which short-run net revenues are maximized subject to resource, financial, and constraints representing safety in investments and in modifying crop patterns. The objective function parameters are based on exogenous prices. The various constraints are modified from year to year according to depreciation and financial feedback and according to rules that represent adaptive response. Given initial conditions and the exogenous variables the model can be run as a sequence of recursively generated LP problems. The various variables and parameters included in the model may be summarized as follows:

1) The endogenous variables include by farm size the production of crops and livestock (by technology--traditional and modern); investment levels in farm power (tractors, harvestors and draft animals); working capital expenditures on machines, fertilizers, seeds, bone meal, concentrates, fuel, etc; borrowings and savings levels and labor utilization by family and wage labor categories, by individual activity, by season and by crop.

2) The exogenous variables include market prices, interest rates, supplies of land and family labor by farm size, wage labor in the region, non-farm incomes and total average propensity to consume out of gross sales in the region.

3) The parameters of the model include input-output coefficients by farm size and regional depreciation rates and adoption and adjustment coefficients by machine type and flexibility coefficients by crop.

We now turn to a brief discussion of how we project the set of exogenous variables for the period 1970-85.

3.4 Assumptions Underlying Policy Projections

The focus of our analysis rests on the wheat price support program and credit subsidies that continue to play a critical role in the development of the region. In view of this emphasis consider the following alternative policy assumptions under which the model can be used to simulate the history of regional production and resource use:

(1) Continuation of Current Programs

Under this set of policy alternatives we assume that current policies which include a domestic price subsidy for wheat above and domestic prices for beef below international price levels are allowed to continue into the future on the basis of currently projected trends. In addition we assume a nominal rate of interest of 10 percent on borrowed capital. In the past since the rate of inflation has exceeded this rate, real interest rates have been negative. Since it was difficult to project rates of inflation for the Brazilian economy we used a nominal rate. The real rate of interest implied by this assumption will depend upon realized rates of inflation in the future. If inflationary trends, already dramatically curbed, continue to decline in the same manner, the implied real rate of interest may be positive under these assumptions.

We further assumed that all other domestic input and output prices projected on the basis of current trends continue to prevail into the future.

The purpose of this model simulation is to enable us to project what is likely to happen in the region if current policies continue substantially unchanged.

(2) Increasing the Nominal Rate of Interest

Using exactly the same assumptions as under (1), we set nominal interest rates at 20 percent instead of 10 percent in the model. The purpose of this is to evaluate the impact of removing credit subsidies if inflationary trends continue to exceed 10 percent. The exact amount of the subsidy (or lack of it) provided by a given assumption on the nominal rate of interest on borrowing will again depend upon the realized rates of inflation in the Brazilian economy.

There are two reasons for analyzing the impact of changes in the interest rates on institutional credit charged to farmers. First, an earlier analysis of the development in the region during the sixties showed that whereas higher rates of interest would have slowed the transition from range livestock to intensive crop production,[11] there were serious distributive and allocative distortions in the use of credit and capital that could have been prevented had credits not been available at negative real rates of interest [5,41,42].

[11] Higher interest rates would not have prevented the transition for once large wheat price supports were put into effect, credit played only an enabling role. See Singh and Ahn [42].

Secondly, there is a growing concern that low interest rates on institutional credits besides encouraging a misallocation of resources and a more capital intensive development, often end up by having major distributive effects as small farmers are denied access as conditions of excess demand prevail [3,16,40].[12]

(3) Introducing International Prices in Output Markets for Traded Goods

Again using the same set of assumptions as under (1), we assume that the same prices for final traded outputs will prevail in domestic markets as those that are likely to prevail in international markets. This consists of substituting the U.S. export prices for wheat and soybeans and the Argentine export price for beef, valued at the going exchange rate, for the respective domestic price vectors. Domestic corn prices are allowed to prevail because it is in main a non-traded good and domestic prices have not differed substantially from international levels once transportation costs have been allowed for. A nominal interest rate of 10 percent is allowed to prevail as in (1).

The outcome of this set of assumptions is to drop the wheat price support program and open domestic output markets to international competition. Although this set of assumptions is somewhat restrictive in that domestic input prices continue to prevail, its purpose is also more specific. It is to investigate what would happen if the current policy of wheat price supports is changed. With domestic beef prices below the international level, the main transformation has involved the substitution

[12] For example, simulation results showed that by 1970 large and medium farms accounted for 70 percent and 28 percent of all borrowings in the region, while small farms accounted for the remainder. During the same year the average productivity of cash outlays on small farms was eight times that on large farms. Ahn [4], Singh and Ahn [42].

of wheat-soybean production for beef production in the region. The focus of analysis then is to see if this process of substitution is reversed when output prices are allowed to fall (rise) to their levels in international markets. The impact of this on regional development and resource use is of considerable additional interest, because by comparing model outcomes under (1) and (3) significant insights can be gained into the impact of price distortions introduced explicitly through policy.

Since input and output prices are exogenous to the model we have used linear time trend equations fitted individually to the time series data, on all domestic input and output prices and international prices for wheat, soybeans and beef, for the period 1964-1970, to project these exogenous variables for the period 1971-1985.[13] Simple price projections on this basis imply that i) although the annual absolute price increase each year remains constant, the rate at which prices increase is declining and ii) the relative price ratios in the period continue to change in the same manner in which they have changed in the period 1964-1970.[14]

---

[13] For data series on input and output prices see Ahn [4].

[14] Although the data for 1960-1963 were available, they are omitted in estimating the domestic time trend equations due to the peak in inflation (more than 100%) between 1963-1964. However, as the Brazilian Government placed an emphasis on controlling inflation beginning in the mid-sixties, all price series show a steadily increasing pattern with an average rate of increase of 20-25 percent per annum (see Conjucture Economica, 1960, . . . , 1970). The trends were fitted using least squares for i) simple linear, ii) semi-log and iii) double-log transformations. While all the regression coefficients were highly significant at 5 percent, the linear equation ($P_t = \alpha + \beta t$) was selected to allow prices to increase annually, but at a diminishing rate, consistent with declining inflationary trends. In addition the R^2 of the linear equations were slightly higher than for the other transformations, all of which had R^2 in excess of .98 for all the time series.

The projected price series for beef, soybeans and wheat in domestic and international markets and used to project the model are shown in Table 3.

We now turn to the model results under the alternative policy assumptions outlined above.

TABLE 3. PROJECTED DOMESTIC AND IMPORT PRICES FOR WHEAT, SOYBEANS AND BEEF IN BRAZIL (1971-1985) IN Cr$/KILOGRAM

	Domestic			International		
r	Wheat (Unmilled)	Soybeans	Beef (Chilled & Frozen)	Wheat (Unmilled)	Soybeans	Beef (Chilled & Frozen)
1	0.5401	0.4055	1.1723	0.3163	0.5397	2.8714
2	0.5973	0.4543	1.2642	0.3489	0.5946	3.1559
3	0.6545	0.5031	1.3561	0.3815	0.6495	3.4403
4	0.7116	0.5519	1.4479	0.4140	0.7044	3.7248
5	0.7688	0.6007	1.5398	0.4466	0.7593	4.0093
6	0.8260	0.6496	1.6316	0.4792	0.8142	4.2937
7	0.8831	0.6984	1.7235	0.5117	0.8691	4.5782
8	0.9403	0.7472	1.8154	0.5443	0.9240	4.8626
9	0.9974	0.7960	1.9072	0.5769	0.9789	5.1471
0	1.0546	0.8448	1.9991	0.6095	1.0337	5.4316
1	1.1117	0.8936	2.0909	0.6420	1.0886	5.7160
2	1.1689	0.9424	2.1828	0.6746	1.1435	6.0005
3	1.2261	0.9912	2.2747	0.7072	1.1984	6.2849
4	1.2832	1.0400	2.3665	0.7397	1.2533	6.5694
5	1.3404	1.0888	2.4584	0.7723	1.3082	6.8539

Source: Projected Price Series.

Prices are projected by the linear time trend equations ($P_t = \alpha + \beta t$) fitted ividually to the time series data (1964-1970) obtained from:

a) Annuario Estatistico do Brasil, 1960-1970, and Annuario Estatistico do Trigo, 1965-1969.

b) Yearbook of International Trade and Statistics, 1960-1970.

c) Annuario Agro-Pecuario, 1960-1970.

d) U.N. Statistical Yearbook.

4. Model Projections

The model provides data on a wide variety of expected outcomes including regional resource use, factor proportion, outputs, average factor productivities, credit use, and farm incomes all by farm size and for the region as a whole. We concentrate here on selected results in order to focus clearly on the policy choices available and their expected outcomes.

We have called the model simulations associated with the policy assumptions described in the last section as i) Base Run, ii) run (R) and iii) run (I), corresponding to assumptions (1) - (3) - that is (1) a continuation of current programs, (2) an increase in the nominal interest rates to 20 percent and, (3) a substitution of interrational for domestic prices for wheat, soybeans, and beef - respectively. These are so shown in figures 1-4.

4.1 Regional Land Use

Model results for regional land use are shown in figure 1. Based on the assumption that current programs are likely to continue these results (marked BASE) indicate that the transition from range livestock to wheat-soybean production, which has characterized the development of the region, specially since 1962 when the wheat price support program was initiated, [BASE], [R] will continue unabated. Wheat hectarage is expected to grow from 0.6 million in 1970 to over 2.8 million by 1985, trebling domestic wheat production. Soybean hectarage (independent and following wheat) will increase even more dramatically from 0.37 million to over 3.3 million a nearly tenfold increase in production.

Most of the increase in crop farming comes through the reduction of natural pasture lands from over 3.1 million in 1970 to about a million hectares

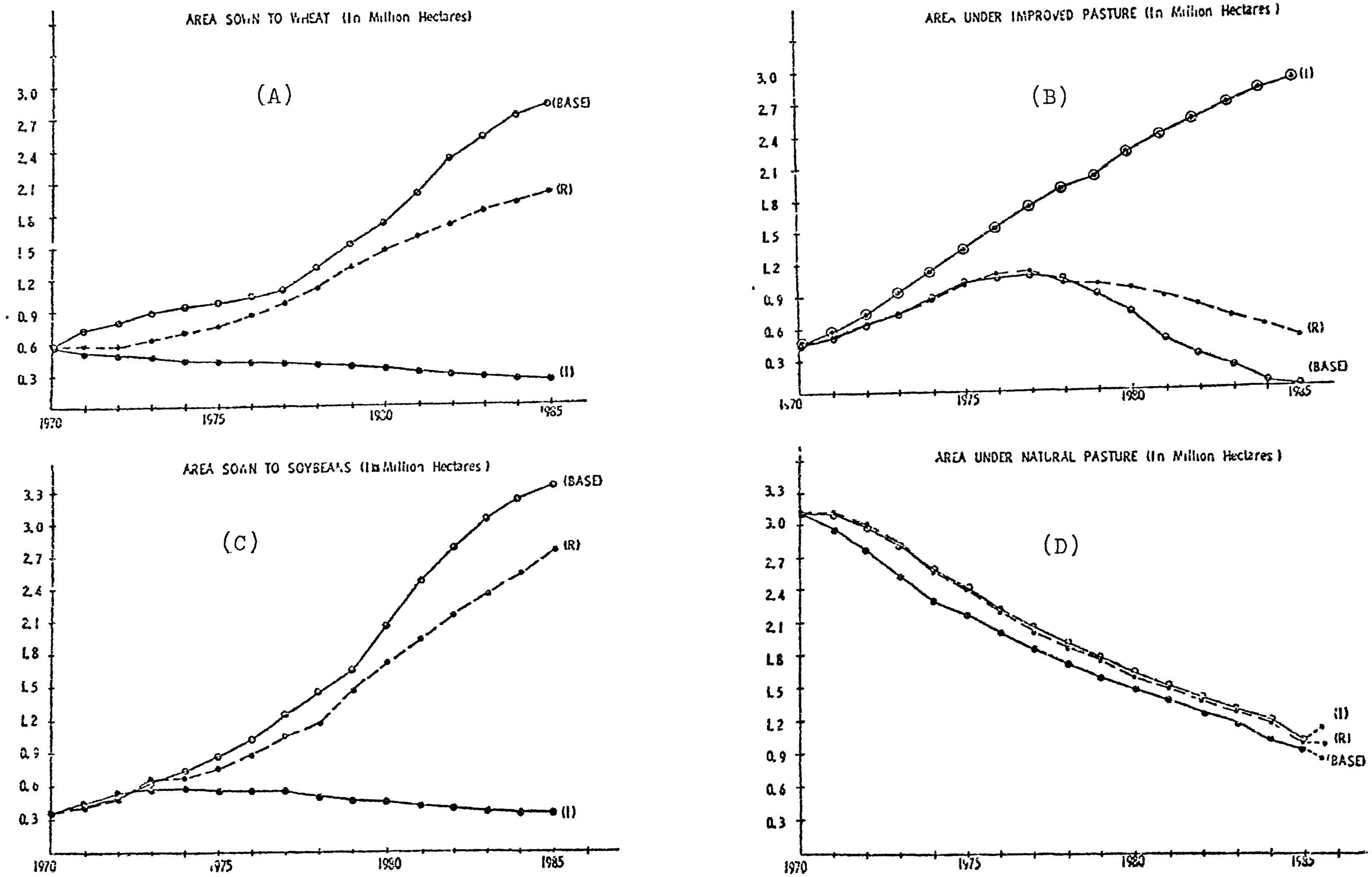

FIGURE 1: PROJECTED LAND USE UNDER ALTERNATIVE POLICY ASSUMPTIONS: WHEAT REGION RIO GRANDE DO IN SOUTHERN BRAZIL(1970-1980)

by 1985. (Fig. 1-C). Beef production on improved pasture systems, which has been increasing in the past, is expected to continue until 1976. (Fig. 1-D). Thereafter it declines, as the domestic wheat/beef price ratio continues to increase, making wheat-soybean double cropping even more profitable, accelerating their growth.

When the nominal interest rate is increased, ceteris paribus, predicted regional land use follows a pattern very similar to the one just described (marked R). Wheat and soybean production increase much slower while beef production under improved pastures declines at a somewhat slower rate after 1976. This is due in large part to the impact of interest rates on the relative profitability of wheat-soybean double cropping which use larger amounts of both variable and investment capital inputs.

On the other hand when international prices for farm outputs are introduced, the model predicts a dramatic change in land use patterns (marked I). Wheat production instead of increasing declines to half its 1970 level, while soybean production after showing some small initial increases remains at its 1970 level. Interestingly enough the economy does not revert to range livestock production, but as beef becomes relatively profitable, the farm capital build up in tractors and harvesting equipment that has already occurred in the transition from range livestock to wheat production, becomes readily available for beef production on improved pastures. Beef production on improved pastures is expected to increase nearly tenfold using the increased area that would have been devoted to wheat production under current programs.

Thus we see that the termination of the domestic price support programs for wheat would mean a reversal in the process of transformation that has characterized the region since the early sixties. Such a reversal would also have an important impact on regional output, employment, and capital use.

4.2 Output, Capital Use, and Employment

Model projections for the value of gross output, total capital use (defined here as outlays on production inputs and the purchase of quasi-fixed inputs), investment outlays (on tractors, harvesters, and draft animals) and total credit use by farm size, under alternative policy assumptions are shown in figure 2.

Under a continuation of current programs value of gross output at constant 1970 prices is expected to grow more than threefold between 1970-85 this will require an almost threefold increase in total capital use (cash outlays on variable inputs and gross farm investments in farm power). Gross investments in farm power (tractors, combines, and draft animals) increase sixfold between 1960-81, declining slowly thereafter. A large part of this growth in investments is due to the mechanization of farm operations. Large and medium farms continue to invest heavily in tractors and combines, partly to avoid seasonal labour shortages and partly to take advantage of the timeliness and efficiency provided by mechanization. After 1975 even small farms feeling seasonal labour shortages begin to mechanize some of their operations.

However, it is clear that not all the impetus to mechanization is due to seasonal labour shortages or efficiency as attended by the dampening effect of increasing interest rates on investment outlays. (figure 2-B).

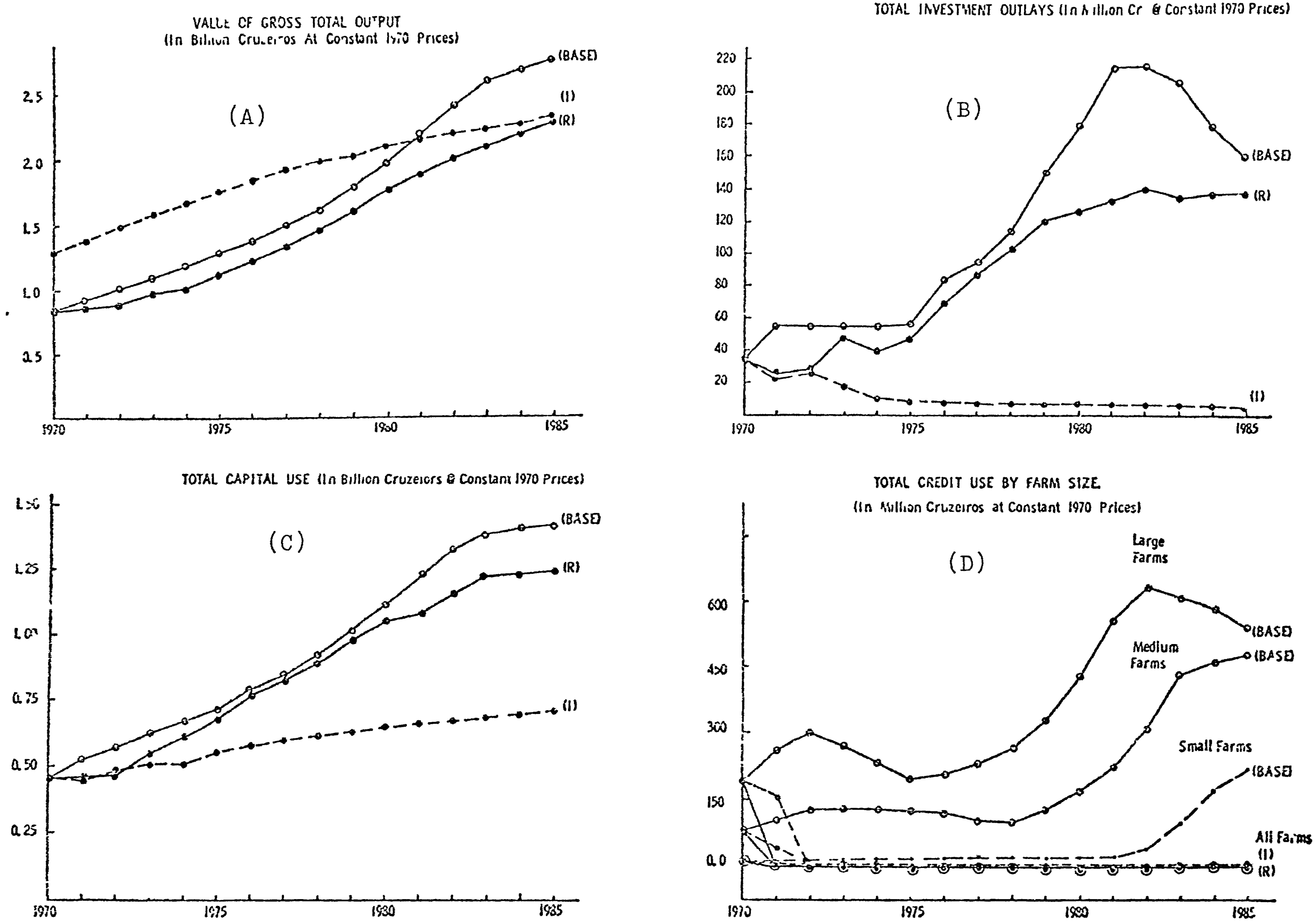

FIGURE 2: PROJECTED GROSS OUTPUT AND CAPITAL USE UNDER ALTERNATIVE POLICY ASSUMPTIONS WHEAT REGION OF RIO GRANDE DO SUL IN SOUTHERN BRAZIL(1970-1985)

In order to finance their increased capital requirements large and medium farms continue to rely heavily on credit (an average of 30% and 50% of the total cash requirements on medium and large farms respectively are met through short term borrowings). Small farms begin to borrow substantial amounts only after 1981 to finance partial mechanization. Total credit use in the region is expected to increase more than sixfold if current programs continue.

Raising nominal interest rates retards the growth of regional output, capital use, and gross investments and reduces the level of borrowings on all farms to zero (see run R in figure 2). This is no doubt a probable under-estimate, but it reflects very clearly the sensitivity of short term borrowings to changes in the nominal rates of interest. This is no doubt due to the fact that the marginal efficiency of capital is highly interest elastic at current interest rates and that the rates of return to capital investments are fairly low. As long as credit at real negative rates of interest is made available to farmers and tied to the purchase of modern inputs used to produce outputs made profitable by a price support program, farmers will be more than willing to increase their indebtedness. However as soon as the real opportunity cost of borrowing is raised, all farms begin to finance their own operations fully, cutting back their capital use at the margin.

But can regional growth be generated without a program of price supports and credit subsidies? The answer is in the affirmative as the substitution of international for the domestic output prices for wheat, soybeans and beef, generate the highest accumulated value for gross output in the region. This is achieved with smaller amounts of total capital use, a very small level of annual gross investments and no credit use (See run 'I' in figure 2). These results are possible because given domestic factor costs and yields, Brazil has a comparative advantage in beef production at prices projected to prevail in the international market.

In addition the employment impact in the region of either keeping or removing the price supports is approximately the same. Regional employment under both programs is expected to nearly double with about 90 percent of the increased employment coming from small farms. The labour use per hectare as expected is inversely related to farm size. (figure 3-B)

Beef production on improved pastures compared to the double cropping of wheat-soybeans usually implies i) a higher labour use per hectare on large and medium farms because beef production is less mechanized and ii) a more stable demand for labour throughout the year as seasonal harvest and land preparation peak loads are not encountered [4].

4.3 Factor Productivity and Farm Incomes

Both the projected ratios of net output per man hour and per unit of capital outlays are shown in figure 3. They indicate that average capital/output ratios are directly related to farm size while average labour/output ratios are inversely related to farm size as expected. Furthermore both average capital and labour productivity are higher when domestic prices are replaced by import prices for traded outputs. (Land productivity is also higher as long as value of output is higher since land is assumed to be a fixed factor).[15]

---

[15] Factor productivities and net farm incomes when only nominal interest rates are raised are not shown.

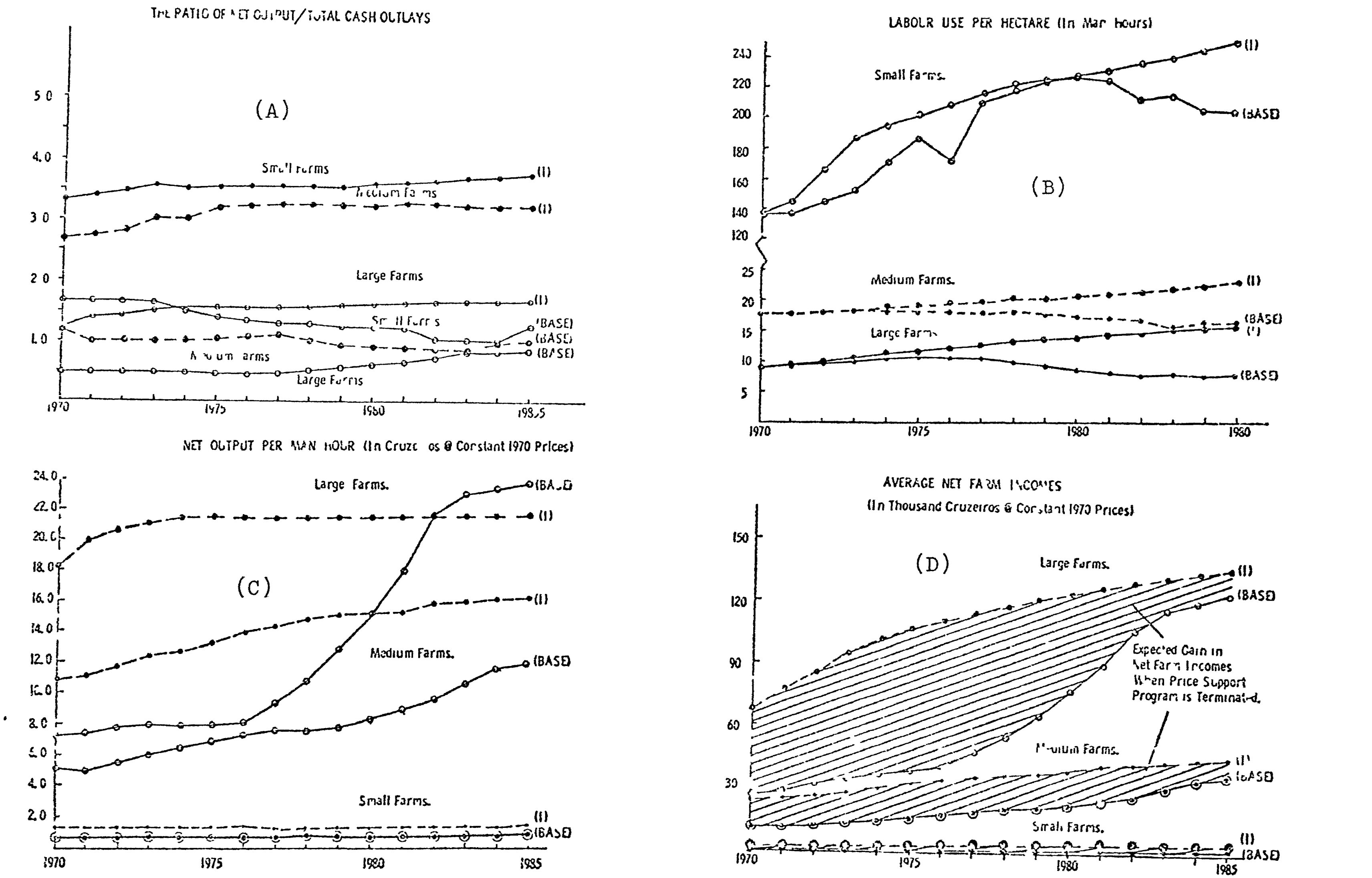

FIGURE 3: PROJECTED OUTPUT/INPUT RATIOS, LABOR USE, AND FARM INCOMES UNDER ALTERNATIVE WHEAT REGION OF RIO GRANDE DOSUL IN SOUTHERN BRAZIL(1970-1985)

The average net farm incomes by farm size are further calculated by assuming that the number of farms in each size group remains unchanged throughout the entire program.[16] Estimated on this basis average net farm incomes (at constant 1970 prices) continue to show dramatic increases on large farms, when current programs are continued, with a nearly fivefold increase between 1970 and 1980. A more moderate threefold increase is experienced on medium farms while on small farms the increase is marginal.

As in the decade of the sixties, policies designed to stimulate regional growth also benefit the larger farms disproportionately and aggravate the problem of income distribution in the region. Thus in 1970 the net farm incomes on large and medium farms were 24 and 10 times higher respectively than on small farms. By 1985 large farm incomes are expected to be more than 40 times small farm incomes.

Again in this regard a program to terminate price supports has beneficial effects. To begin with, gains in net farm incomes are expected when price support programs are terminated (figure 3-D). In addition, though income inequality increases, this increase is less rapid. Thus by 1985 net farm incomes on large farms are only 34 times those on small farms.

In comparing expected model outcomes under alternative policy assumptions we have indicated that the termination of current price support programs in favour of letting the international output prices prevail can have a variety of desirable effects: i) accumulated output growth is expected to be larger, ii) less capital is used and probably more efficiently, iii) total credit use is negligible,releasing credits for use elsewhere, iv) labour

---

[16] Not enough census data to date are available to allow a projection of the distribution of farms by size.

land and capital productivities are likely to be higher on all farms, v) employment increases equal to those obtained under alternate programs are likely to have less seasonal fluctuations and vi) average net incomes on all farms are expected to be higher and vii) the increase in income inequalities is likely to be less rapid.

It would seem that on the basis of this evidence, partial though it is, it becomes possible to evaluate the relative costs and benefits of alternative programs and to make tentative policy recommendations. This we attempt to do briefly in the next section.

5. Evaluation of Policy Alternatives and Implications

It is enticing to draw specific policy recommendations on the basis of our analysis, but this temptation must be restricted for several reasons. First, though the model attempts to incorporate many microeconomic details in order to track the process of regional development, it also has to abstract and aggregate considerably for various practical reasons. It is more detailed than many models that vary only on aggregate indices, for an attempt has been made to construct it in a "bottom-up" manner, with input/output data obtained from detailed farm surveys. To the extent that it is based on a detailed knowledge of agriculture in the region, it is fairly "realistic". Furthermore, considerable theoretical support and applied experience lie behind the model components and aggregation procedures used here [7,8,12,13,19]. However, caution is still advisable.

Second, in capturing many of the details its structure is complex, and its very complexity prevents the use of any straight forward procedures for testing its goodness of fit. This is made more difficult by the unavailability of regional data in sufficient details to test the variables estimated by the model and by the usual inaccuracy in the data. Model tests for the period 1960-1970 were made before we attempted this exercise. We felt that the model was able to track recent events closely, and the testimony of regional experts tended to confirm it. But no statistical significance can be attached to the variety of non-parametric tests often used[17] in evaluating complex simulation models of this kind.[18]

In using such models to project future outcomes one needs to be aware of the conditional nature of the predictions. More specifically even if the model structure was fully validated, its predictions are conditional upon the assumptions under which the exogenous input and output price data are projected in both domestic and international markets. This has to be clearly borne in mind.

Thirdly, the model is partial and region specific so that policy recommendations that flow from it can at best be partial and region specific. This drawback is partially overcome if we consider the model to be fairly representative of the wheat commodity sector in Brazil as the wheat region modelled accounted for over sixty percent of the total production as well as the area sown to wheat in Brazil in 1970. Given its past performance its share of total domestic production is likely to increase rather than decrease.

Nevertheless, given these qualifications, let us focus clearly on two

---

[17] In spite of serious difficulties, methodoligical and practical, in arriving at evaluation criteria, several methods have been developed to evaluate such models.

[18] See Johnson and Rausser [24] for a discussion of problems in developing evaluation criteria and Day and Singh [12] for several evaluation techniques that can be used. For a detailed evaluation of the current model see Ahn [4] and Singh and Ahn [42].

distinct policy choices: i) to let current programs continue or ii) to terminate price supports for wheat and let output prices fall (rise) to their level in international markets. Given the limited partial data what can we say about the relative costs and benefits of these alternative programs?

5.1 Direct Costs of Alternative Programs

To begin with there are direct costs associated with the current program that could be saved if the program was terminated. These include the wheat price supports and the credit subsidies and can be easily measured. The direct costs of wheat price supports can be measured by multiplying the difference between the domestic and import price of wheat per hectare of output by the differences in wheat hectarage predicted under the two programs.

The credit subsidy that will prevail in the future is more difficult to estimate, since we need to know both the real opportunity cost of capital to farmers in the region, as well as the rate of inflation. Alternatively we need to know the difference between the rate of interest that will prevail in open financial markets and the rate charged on institutional credit. We make the simplifying assumption that this will be a uniform five percent for all years up to 1985.[19] The cost of credit subsidy is then five percent of the difference in total regional borrowings under the two programs, predicted by the model. Since there were no borrowings under the second program, this reduces to five percent of the borrowings under the current program. These

---

[19] This is probably an underestimate if one reviews the rate of inflation and the differences between rates in open markets and institution rates in the past decade.

direct costs discounted at ten percent per annum are shown in Table 4.

These indicate that the net losses due to the direct costs associated with price supports and credit subsidies are Cr.$2,127.6 million and Cr.$971.5 million respectively, if current programs are compared with the alternative. This is an average annual loss of Cr.$206.6 million. This direct cost does not include any administrative costs of the price support and credit programs, which should also be included. We have no data on these costs.

5.2 Indirect Costs of Alternative Programs

In addition to the differences in direct costs we see that the two programs generate two different paths for regional output. As price supports are terminated and international prices are allowed to prevail in domestic markets, outputs are priced at those prices. Thus lower wheat prices and production are offset by higher beef prices and production. Furthermore, the domestic costs for production also change under the two programs. Therefore an appropriate measure for the indirect costs (benefits) associated with the programs is the differences in the value of net domestic output generated under the two programs. These are shown in Table 5, and discounted at ten percent per annum indicate that the loss in the value of net output associated with the continuation of current programs is Cr.$4,326 million over the fifteen year period. These indirect costs of Cr.$288.4 million per annum can be added to the direct costs of $206.6 per annum to give us a measure of the average annual loss associated with continuing current programs, compared to the alternative. These add up to a net loss of approximately of Cr.$495 million annually if current programs

TABLE 4; ESTIMATED DIFFERENCE IN DIRECT COSTS ASSOCIATED WITH TWO POLICY RUNS

YEAR	Wheat Hectarage (1000 Hectares) BASE (1)	I (2)	Discounted Direct Costs of Price Supports [b] $\frac{(1-2)\times \Delta P}{(1+0.10)^t}$ [a]	Discounted Direct Costs of Credit Subsidies [b]
1971	702.0	535.9	137.144	128.447
1972	811.4	501.7	144.106	105.040
1973	889.5	469.6	143.616	80.703
1974	933.7	454.6	137.047	55.221
1975	967.1	442.2	129.045	33.155
1976	1,071.8	421.2	130.014	23.875
1977	1,172.7	395.9	129.322	17.844
1978	1,306.5	372.2	130.979	19.348
1979	1,508.5	349.9	137.482	30.004
1980	1,742.0	329.1	144.329	46.731
1981	2,014.3	309.5	151.719	69.288
1982	2,302.1	291.1	157.633	85.283
1983	2,534.6	274.0	157.775	95.030
1984	2,702.1	257.8	152.911	94.519
1985	2,808.0	242.6	144.458	87.032
		Total	Cr.$ 2,127.580	Cr.$ 971.520

(a) Δ P is the price difference between domestic and international wheat price in 1970 (499.8-284.9 Cr.$/Ha)

(b) Discounted at 10 percent per annum, and estimated at constant 1970 prices.

TABLE 5. ESTIMATED DIFFERENCES IN INDIRECT COSTS ASSOCIATED WITH TWO POLICY RUNS

	Net Domestic Outputs (Million Cr. $)[(a)]		Discounted Differences in Value of Net Domestic Outputs (Million Cr. $)[(b)]
YEAR	BASE	I	
1971	391.716	910.650	-471.758
1972	437.250	988.312	-455.422
1973	478.906	1,074.255	-447.294
1974	515.296	1,144.049	-429.446
1975	547.702	1,208.503	-410.305
1976	584.815	1,268.109	-385.701
1977	645.207	1,323.207	-347.921
1978	703.421	1,373.536	-312.613
1979	773.146	1,417.473	-273.257
1980	868.366	1,462.825	-229.189
1981	977.275	1,500.886	-183.522
1982	1,096.897	1,538.558	-140.726
1983	1,229.343	1,572.393	- 99.369
1984	1,308.168	1,604.353	- 77.994
1985	1,375.720	1,634.361	- 61.916
		Total	-4,326.433

(a) At constant 1970 prices.

(b) Discounted at 10 percent per annum.

continue substantially unchanged.[20]

5.3 Domestic Resource Costs of Import Substitution

Another way to look at the highly successful program of price supports for wheat is to recognize that it is an attempt at import substitution in wheat production. Following Krueger [26] we can analyze the efficiency of the Brazilian "import substitution" program for wheat by using the domestic resource cost (DRC) concept used by her and others.[21] The DRC measures the opportunity costs of the domestic resources employed directly in the i^{th} output industry as a fraction of the net change in the country's trade balance that would occur were the level of the i^{th} output contracted (expanded) by one unit, and is defined as follows:

$$DRC = DC_i / NVA_i$$

where DC_i is the net opportunity cost of domestic resources employed per unit of output and NVA_i is the net international value-added per unit of output in the ith industry.

---

[20] Of course a measure of true welfare losses can only be obtained if all inputs and outputs are priced at their social opportunity cost. We have already priced outputs at international prices. In addition it should be noted that those inputs that are likely to be underpriced in domestic compared to international markets - like tractors, combines - are used in larger amounts for wheat-soybean production than for beef production. Thus these estimates of welfare losses associated with the continuation of current programs are probably an underestimate. In addition one must include administrative costs for which we have no data.

[21] For theoretical discussions and applications of DRC see Krueger [26]. For an empirical application to the Indian caustic soda industry, see Starr [44]

We have made these calculations for wheat production in 1970 on a per hectore basis in Table 6. To estimate the DRC for wheat we have assumed that all factor inputs used in wheat production are obtained from domestic sources.

These estimates give the direct resource cost for wheat production at 6.63 Cr.$/$. This implies that in 1970 it costs the Brazilian economy 6.63 Cr.$ to obtain one dollar's worth of value added, at international prices, through the domestic production of wheat. Comparing this with the ratio of 4.57 for the free market exchange rate between Cruzerios and U.S. dollars, we see that the DRC for wheat is such that Brazil could have imported 1.45 times the value of imported goods for every unit of wheat produced domestically.

The DRC provides a measure of the loss in terms of the value of imports forgone as a result of import substitution in wheat. We have the model predictions for the total domestic resource costs for each year (DC(t)) and the value of total output at international prices. We can use the same method of analysis to calculate the losses in foriegn exchange in each year as a consequence of import substitution in the wheat region. These figures are shown in Table 7. They indicate that the losses in foreign exchange as a result of the continuation of the current program of import substitution in wheat are expected to be U.S. $563.6 million over a 15 year period - or an average annual loss of U.S. $36.7 million.

Table 6. Domestic Resource Costs for Wheat Production in the Wheat Region in 1970.

Domestic Costs of Inputs* (per Hectare of Wheat Output)	
Land (1ha) : Rental Value	: 82.66
Labor (9 hrs)	: 7.66
See (9 kg)	: 63.0
Insecticide	: 8.11
Soil Fumigant	: 5.43
Tractor Oper. Co. (5 hrs)	: 22.75
Fertilizer (250 kg)	:105.00
Combine Oper. Co. (1 hr)	: 11.32
Transportation (1,360 kg)	: 19.04
Depreciation of Tractor	: 6.00
Depreciation of Combine	: 20.40
Administration	: 21.50
Compulsory Insurance	: 3.5
Fertilizing and Seeding	: 16.5
Interest on Short-Term Borrowing	: 17.5
Tax and Registration	: 2.85
TOTAL DC	Cr$ 413.22

Net Value Added in International Markets**: U.S.$62.33

DRC for Wheat = 413.2/62.3 = 6.63

Current Exchange Rate : Cr$/U.S.$ = 4.572
(In 1970)

---

* Source : (1) Trigo : Estudo Do Custo De Producas, Safra De 1971, 1972
(2) Ahn [4] and Engler [14]

** An output of 1,020kg per hectare valued at the U.S. export price of $0.061105 per kg. in 1970

Table 7. Projected Total Domestic Costs, Import Costs and Foreign Exchange Forgone Through Import Substitution in Wheat Production (1970-1985).

Year	Area Sown to Wheat (1,000 Ha)	Total Domestic Costs of Production[(a)] (In Million U.S. $)	Equivallent Import Costs [(b)] (In Million U.S. $)
1971	576.9	52.140	35.956
1972	665.4	60.139	41.472
1973	718.1	64.902	44.757
1974	732.6	66.212	45.661
1975	740.6	66.935	46.159
1976	824.1	74.482	51.363
1977	909.3	82.183	56.674
1978	1,030.1	93.101	64.203
1979	1,239.5	112.026	77.254
1980	1,492.4	134.883	93.017
1981	1,769.0	159.883	110.256
1982	2,058.5	186.048	128.300
1983	2,293.2	207.260	142.928
1984	2,465.5	222.788	153.667
1985	2,577.9	232.991	160.672
TOTAL		1,815.973	1,252.339

Foreign Exchange Forgone = 1,815.9 − 1,252.3 = 563.6 Million U.S. $.

a) Total Domestic cost of wheat production at 1970 prices = Area Sown to Wheat x Cr$413.2 from Table 6. ; converted into U.S. dollars at the free market exchange rate of 4.572 Cr.$/$.

b) Value of Equivalent imports of wheat at the U.S. export price of $61.105 per metric ton in 1970.

5.4 Policy Implications

It would appear on the basis of the above calculations that a continuation of import substitution in wheat through a program of price supports is less desireable than an alternative program that would allow output prices in domestic markets to approach their international level. Besides a net savings in foreign exchange of U.S. $ 36.7 million annuallly, such a change in policy would result in higher net social benefits of approximately Cr.$ 495 million annually in the region.

As we have shown such a change also has other desireable consequences from the point of view of reducing the growth in income inequalities and providing more stable employment without reasonal peakloads through the year. Farm factor productivities are also likely to rise while a dampening of capital use and gross investments is likely to lead to a more efficient use of capital.

In addition, the price of wage goods is likely to fall as the domestic price of wheat is reduced, even though beef prices may increase. Furthermore institutional credit, no doubt a scarce factor, that is now being used will be released for use in other regions and sectors, leading to greater overall growth for the economy.

There are therefore many cogent reasons on the basis of which one could recommend a termination of the import substitution in wheat through a program of price supports. Yet one hesitates to recommend this because the alternative program would mean an increasing dependence on foreign markets. This dependence would come from the need to import the domestic requirements for wheat, and the need to find export markets for beef.[22] Whereas the prospects for increasing beef exports are reasonable given the current shortage in world markets, the prospects of importing wheat to meet growing domestic demand are not so good. A reliance on international markets introduces a large element of uncertainty in the development program in any country and has to be properly taken into account.

Thus the desireability of terminating wheat support program has to be further evaluated in terms of the situation in international markets for wheat, beef and soybean. This is beyond the scope of the current paper.

6. Conclusions

We have used a dynamic microeconomic model to simulate the possible future outcomes under alternative policy specifications for the wheat region in Rio Grande do Sul. It was enabled us to evaluate the possible benefits to be derived from the termination of the current program of import substitution in wheat. However, the program of "self-sufficiency" that initiated these policies, if it is to be continued,must be justified on the basis of arguments about the uncertainty with regard to the ability of Brazil to import its needs for wheat and export its surplus beef production. These issues need careful and detailed research before they can resolve the conflicting claims of the alternative programs analysed.

---

[22] Some estimates place the total domestic demand for wheat and beef by 1975 at 5170 and 3390 thousand metric tons respectively. (See Schuh [36] p.370-371)

REFERENCES

1. ABE, M. (1969), "A Dynamic Analysis of Investment and Technological Change in the U.S. and Japanese Steel Industries," Unpublished Ph.D. Dissertation, University of Wisconsin, 1969.

2. ADAMS, Dale W. (1971), "Agricultural Credit in Latin America: A Critical Review of External Funding Policy," American Journal of Agricultural Economics, Vol. 53 (2), May 1971.

3. ADAMS, Dale W (1973), "The Case For Voluntary Savings Mobilization:Why Rural Capital Markets Flounder," unpublished analytic paper prepared for the AID Spring Review of Small Farmer Credit, sponsored by the Agency for International Development, Washington, D. D., July, 1973.

4. AHN, C. Y. (1972), A Recursive Programming Model of Regional Agricultural Development in Southern Brazil (1960-1970): An Application of Farm Size Decomposition, Unpublished Ph.D. Dissertation, Ohio State University, 1972.

5. AHN, C. Y. and I. J. Singh (1972), "Distribution of Farm Incomes Under Alternative Policy Regimes: A Dynamic Analysis of Recent Developments in Southern Brazil (1960-1970)," A paper presented at the Annual Meeting of the AAEA, Gainesville, Florida, August 1972.

6. BOUSSARD, J. M. (1969), "The Introduction of Risk into Programming Models: Different Criteria and Actual Behavior of Farmers," European Economic Review, Vol. I (11), 1969.

7. CIGNO, A. (1969), "Production and Investment Response to Changing Market Conditions, Technical Know-How, and Government Policies--A Vintage Model of the Agricultural Sector--," A Discussion Paper, University of Birmingham, England.

8. DAY, Richard H. (1963), Recursive Programming and Production Response, Amsterdam: North-Holland Publishing Co., 1963.

9. DAY, Richard H. (1963), "On Aggregating Linear Programming Models of Production," Journal of Farm Economics, Vol. XLV (4), November 1963.

10. DAY, Richard H. (1969), "More on the Aggregation Problem: Some Suggestions," American Journal of Agricultural Economics, Vol. 51 (3), August 1969.

11. DAY, Richard H., M. ABE, W. TABB and C. TSAO (1969), "Recursive Programming Models of Industrial Development and Technological Change," Contributions to Input-Output Analysis (A.P. Carter and A. Brody, Eds.), Amsterdam: North Holland.

12. DAY, Richard H. and I. J. SINGH (1973), "Economic Development as an Adaptive Process: A Green Revolution Case Study," paper No.7310, Social Systems Research Institute, University of Wisconsin, April 1973..

13. DE HAEN, Hartwig (1971), Dynamisches Regional Modell der Production Und Investition in der Landwirtshaft, Hannover, Alfred Strothe Verlog, 1971.

14. ENGLER, J. J. de C. (1971), "Alternative Enterprise Combination Under Various Price Policies on Wheat and Cattle Farms in Southern Brazil," Unpublished Ph.D. Dissertation, Ohio State University, 1971.

15. ENGLER, J. J. de C. and I. J. SINGH (1971), "Production Response to Technological and Price Changes: A Study of Wheat and Cattle Farming in Southern Brazil," A Contributed Paper presented at the annual meeting of the AAEA in Carbondale, Illinois, August 1971.

16. GONZALES-VEGAS, Claudio (1973), "Interest RAte Policies and Small Farmer Credit Programs in LDC's" unpublished analytic paper prepared for the AID Spring Review of Small Farmer Credit, sponsored by the Agency for International Development, Washington D. D., July 1973.

17. HAYAMI, Yujiro and V. W. RUTTAN (1971), Agricultural Development: An International Perspective, The Johns Hopkins Press, 1971.

18. HEADY, E. D., W. B. BACK and E. A. PETERSON (1953), "Interdependence Between the Farm Business and the Farm Household with Implications for Economic Efficiency," Research Bulletin No. 398, Agricultural Experiment Station, Iowa State College.

19. HEIDHUES, Theodor (1966), "A Recursive Programming Model of Farm Growth in Northern Germany," Journal of Farm Economics, 48: pp. 668-684.

20. HENDERSON, J. M. (1969), "The Utilization of Agricultural Land: A Theoretical and Empirical Inquiry," The Review of Economics and Statistics, Vol. XLI, No. 3 (August, 1959), pp. 242-259.

21. HILLER, F. S. and G. J. LIEBERMAN (1967), "Introduction to Operations Research. San Francisco, California: Holden-Day, Inc., 1967.

22. HOPPER, W. David (1965), "Allocation Efficiency in Traditional Indian Agriculture," Journal of Farm Economics, Vol. 47 (3), August 1965.

23. JOHNSON, Glenn L., et. al. (1971), A Generalized Simulation Approach to Agricultural Sector-With Special Reference to Nigeria, Michigan State University, November 1971.

24. JOHNSON, S. R. and G. C. RAUSSER (1972), "Notes on Verification Problems for Systems Models," a paper presented at the A.D.C. Conference on General Systems Analysis Approach to Agricultural Sector Analysis at Airlee, West Virginia, May 1972.

25. KNIGHT, Peter T. (1971), Brazilian Agricultural Technology and Trade - A Study of Five Commodities, New York, New York: Praeger Publishers, Inc., 1971.

26. KRUEGER, Anne O. (1966), "Some Economic Costs of Exchange Control: The Turkish Case," Journal of Political Economy, Vol. LXXIV, No. 5, October 1966.

27. LASDON, Leon S. (1970), Optimizing Theory for Large Systems, The Macmillan Co., New York, 1970.

28. MELLOR, John W. (1965), "The Subsistence Farmer in Traditional Economies," Paper presented at the A.D.C. Seminar on Subsistence and Peasant Economies, East-West Center, Honolulu, Hawaii, February-March 1965.

29. MILLER, T. A. (1972), "Evaluation of Alternative Flexibility Restraint Procedures for Recursive Programming Models Used for Prediction," A.J.A.E., Vol. 54, No. 1, Feb. 1972.

30. MUDAHAR, M. S. (1972), Recursive Programming Models of the Farm Sector With Emphasis on Linkages with Nonfarm Sector: The Punjab, India, Unpublished Ph.D. Dissertation, University of Wisconsin, 1972.

31. NELSON, Jon P. (1970), "An Interregional Recursive Programming Model of the U.S. Iron and Steel Industry: 1947-1967," Unpublished Ph.D. Dissertation, University of Wisconsin, 1970.

32. PETIT, M. and J. M. BOUSSARD (1967), "Representation of Farmers' Behavior Under Uncertainty with Focus-Loss Constraint," Journal of Farm Economics, Vol. 49, November 1967.

33. RASK, Norman (1969), "Analysis of Capital Formation and Utilization in Less Developed Countries," Terminal Report for Research Project, Occasional Paper No. 4, Department of Agricultural Economics and Rural Sociology, Ohio State University, December 1969.

34. RASK, Norman (1971), "Analysis of Capital Formation and Technological Innovation at the Farm Level in LDC's," Second Annual Report for Research Project, Occasional Paper No. 35, Ohio State University, July 1971.

35. ROY, A. D. (1952), "Safety First and the Holding of Assets," Econometrica 20: 431-448, 1952.

36. SCHUH, G. Edward (1970), The Agricultural Development of Brazil, New York, N. Y.: Praeger Publishers, Inc., 1970

37. SCHULTZ, T. W. (1964), Transforming Traditional Agriculture, New Haven: Yale University Press.

38. SHACKLE, G. L. S. (1958), Time in Economics, North-Holland Publishing Co., Amsterdam, 1958.

39. SINGH, I. J. (1971), "A Recursive Programming Model of Traditional Agriculture in Transition: A Case Study of the Punjab, India," Ph.D. Dissertation, University of Wisconsin, 1971.

40. SINGH, I. J. (1973), "The Need for Flexibility in Small Farmer Credit Programs," unpublished analytic paper prepared for the AID Spring Review of Small Credit, sponsored by the Agency for International Development, Washington D. C., July 1973.

41. SINGH, I. J. and C. Y. AHN (1972), "Employment and Capital-Labor Substitution in South Brazillian Agriculture," Occasional Paper No. 72, Department of Agricultural Economics and Rural Sociology, The Ohio State University, 1972

42. SINGH, I. J. and Choong Y. AHN (1972), "A Dynamic Model of Agricultural Development in Southern Brazil: Some Retrospective Policy Simulations (1960-1970)," A paper presented at the Agricultural Development Council Conference on the Application of Recursive Decision Systems in Agricultural Sector Analysis, November 1972.

43. SMITH, Gordon W. (1969), "Brazilian Agricultural Policy, 1950-1967," in (ed.) Howard S. Ellis, The Economy of Brazil, University of California Press, Berkeley and Los Angeles, 1969.

44. STARR, Edward G. (1970), "The Cost of Import-Substitution: The Case of the Indian Caustic Soda Industry," Unpublished Ph.D. Thesis, University of Minnesota, November 1970.